

ANALYSIS OF THE STRENGTHS AND THE WEAKNESSES OF PROTOTYPE I: INQUIRY-BASED LAB MANUAL IN ACID BASE CHAPTER

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Abstract

The study aimed at determining the strengths and the weaknesses of each prototype obtained in the development of Inquiry-Based Lab Manual in Acid Base Chapter. This article was limited to the analysis of the prototype I. Based on the literature review, analysis of needs and student learning outcomes, researcher identified that the experiments presented in Basic Chemistry Lab Manual based on confirmation or verification that provided little opportunity for students to develop an understanding of concepts, skills and abilities possessed by students. Therefore, development of inquiry-based lab manual was required for giving students the opportunity to seek and find knowledge independently through practical learning in the laboratory. This research used development research method which was limited in developing product, validating product, testing the practicality of product, and conducting product trial in Basic Chemistry Lab II class. The instrument for practicality test of the prototype I was a questionnaire that contained 15 descriptors with five alternative answers and score ranged 1-5 and accompanied by the comment column. Based on questionnaire data analysis, the score was of 4.20. This showed that the prototype I belonged to the category of practical and feasible guiding students in conducting laboratory experiments. Based on the analysis of student comments, the prototype I had strengths and weaknesses in terms of design, language and content so it needed to be revised and trial at a further step.

Keywords: The Strengths and The Weaknesses, Inquiry-based Lab Manual in Acid Base Chapter

INTRODUCTION

Basic Chemistry is one of courses which discusses about properties, characteristics, principles, concepts, compositions or transformation of matter. Students in Chemistry Education Study Program should take this course in order to obtain the essential concept, apply it in daily life and also can resolve problems related to the concept not only in theoretical way but also experimental one. This course is supported by Basic Chemistry Lab II. Students are expected to master some basic skills that can support the process of laboratory experiments in order to run properly. Students are forced to be more active in practical activities than classroom learning and required to seek and find their own answers by conducting experiments independently (Roestiyah, 2012). Basic Chemistry Lab II contains five topics: solution, rate of reaction, electrochemistry, inorganic chemistry, and organic chemistry. According to student learning outcomes data in Chemistry Education Study Program, FPMIPA, Sriwijaya University in the academic year

2012/2013 , the lowest score was for solution chapter especially in acid base titration part. Percentage of students who received grades of A, B, C, D, and E respectively: 8,47 %, 52,24 %, 38,98 %, 0.0 %, and 0.0 % (quotation list of values in Chemistry Education Study Program, FPMIPA, Sriwijaya University). It shows that students' achievement weren't evenly distributed in mastery of acid base concepts. That's the reason why we chose this chapter as our focused.

Students, who conduct experiments in the laboratory, always use Basic Chemistry II Lab Manual as a guideline. Based on the literature review and needs assesment, type of experiment presented in lab manual based on confirmation or verification It directs students to prove theories or concepts learned from books and lecturers (oriented material substance) by following step by step of procedures that has been provided in the lab manual (Kanli & Yagbasan, 2006). Basically, students who follow it have known theoretical before finding proof by experiment (Fay, Grove, Towns, & Stacey, 2007). Hofstein, Navon, Kipnis and Naaman (2004) stated that students who conduct experiments based on confirmation have little opportunity to figure out the concepts and develop their skills compared to inquiry based experiments. Therefore, based on the analysis, it is required to develop inquiry-based lab manual to provide an opportunity for students to explore and discover on their own knowledge through learning laboratory experiments.

In addition, we did a review of Basic Chemistry II lab manual based on Inquiry approach. The results showed the strengths and the weaknesses of Basic Chemistry II Lab Manual. The strengths: 1) oriented to material substance, 2) the experiments were derived from the simple to the complex, 3) the literature review contained the concepts of acid base topic and it described in a simple and sequential way, 4) the phrase used in the procedure was easy to understand and in accordance with the level of student understanding. The weaknesses: 1) the amount of equipment and chemicals required in the experiments was not mentioned, 2) there was no questions and tasks that directed students to draw conclusions, 3) experiments described in the lab manual didn't encourage students to practice and find the concept independently, 4) it had not been associated with the concept of chemistry in daily life, and 5) there was a gap between the topics which were discused in Basic Chemistry II course and in lab course. Therefore, we planned to develop inquiry-based lab manual to overcome these deficiencies. The development of inquiry-based lab manual in Basic Chemistry Lab II is expected to encourage students to find a concept or new knowledge through experiments so that the acquired knowledge will be meaningful.

The research consists of five steps. It will result a draft, three prototypes and a final produt, inquiry-based lab manual, in the fifth step. This article is limited to the analysis of the prototype I, so the problems of this research are:

1. *What are the strengths and the weaknesses of prototype I (inquiry-based lab manual)?*
2. *How are the validity and practicality of prototype I (inquiry-based lab manual)?*

THEORITICAL FRAMEWORK

Inquiry Based Learning

Jean Piaget argued that knowledge is not passively received by a person but by action (Yamin, 2011). According to Piaget, basically someone since childhood had the ability to construct his own knowledge so that knowledge will be meaningful if sought and found himself by someone (Sanjaya, 2009). His statement generated a learning theory known as the theory of constructivism.

According to Sagala (2010), constructivist theory is the idea that one must find and transform complex information into other situations and when desired information would be theirs. Thus the theory of constructivism basically emphasizes a learning that encourages a person to construct their own knowledge is in itself not accept the knowledge of others. As a theory that emphasizes the thinking process then constructivism brings about a variety of learning which is based on this genre, which includes discovery learning, problem-based learning, contextual-based learning, and inquiry-based learning.

National Academy of Sciences (1996: 214) revealed "inquiry is a set of interrelated process by the which scientists and students pose questions about the natural world and Investigate phenomena; in doing so, students acquire knowledge and develop a rich understanding of concepts, principles, models and theories". Inquiry is a thought process that starts from questions about natural phenomena and certain discovery, by way of formulating problems, planning experiments, conducting experiments, collecting and analyzing data and drawing conclusions, which will build and enrich the knowledge that already exists within someone.

Anderson revealed that the inquiry-based learning (IBL) will build a knowledge, understanding and scientific thought that someone should understand how scientists learn about natural phenomena (Ogus-Unver & Arabacioglu, 2011). Meanwhile, according to Fitriyanti (2008), in Inquiry-based learning, a person is required to obtain the knowledge and skills of the result of finding themselves not remembering or memorizing. Based on these descriptions, the inquiry-based learning is learning strategies in which students build knowledge through a series of activities to seek and find the answers of problems and construct the information obtained by the existing knowledge so it will build a knowledge, understanding and meaningful scientific thinking and specific skills. The general steps of Inquiry based learning can be described as below, (Sanjaya, 2009):

1) Orientation

Orientation step is the stage where the lecturers raise up a responsive learning atmosphere so the students are ready to implement the learning process as well as stimulate and encourage students to plan a problem solving.

2) Formulating the Problem

At this stage, lecturers bring students to an issue that challenges students to think in solving the problem.

3) Proposing the Hypothesis

Lecturer will give an opportunity to the students to guess or figure out the answer of the problem. In this stage lecturers encourage students to propose hypothesis or give a variety of possible answers for the problem based on the concepts.

4) Collecting Data

At this stage lecturers encourage students to think what information is needed and how to obtain that information.

5) Testing Hypothesis

Testing the hypothesis is the process of determining an answer that is considered acceptable in accordance with the data or information obtained by data collection.

6) Drawing Conclusion

Furthermore, at this stage lecturers encourage students to describe the findings based on the results of hypothesis testing. In this case if the data obtained in accordance with the hypothesis and relevant so conclusions obtained will be relevant, and vice versa.

The sixth stage is basically integrated with each other where emphasizes on activities to seek and find in order to develop students ability to think in a rational, logical, and critical way.

Inquiry-Based Basic Chemistry II Lab Manual

Teaching materials are all forms of material used to assist teachers in conducting teaching and learning activities in the classroom and also as a means to guide students in the learning process (Rupiah, 2010). Teaching materials include handouts, books, modules, student worksheets, practical guide, dictate, hardware and software. Teaching materials used in chemical lab activities are chemistry lab manual. Trianto (2010) disclosed that the preparation of lab manual should consist of the title of the experiment, a brief theory of matter, tools and chemicals, procedure, data observation as well as questions and conclusions for discussion. According to Farikhayati (2009), preparing lab manual should pay attention to the content of lab manual, manual organizations, sentence clarity and readability, as well as physical appearance of lab manual. The lab manual is expected to motivate the students to carry out practical activities to acquire meaningful knowledge in the laboratory.

Lab manual that will be developed is inquiry-based lab manual for Acid Base chapter which contains inquiry syntax: orientation, formulating the problem, proposing hypothesis, collecting data, testing hypothesis and drawing conclusions by following the rules of scientific writing.

Research and Development

One of research and development (R & D) models in education field proposed by Borg and Gall (1983). According to them, this model is a process to develop and validate educational products. Stages of R & D by Borg and Gall (1983) include: (1) research and information gathering, (2) planning, (3) design the initial product, (4) limited-scale

testing, (5) major product revision, (6) large-scale testing, (7) operational product revision, (8) field testing, (9) final product revision, and (10) dissemination. On the development of learning materials Thiagarajan et al., (1974) made a summary into four phases: define, design, develop, and disseminate (known as the 4D Model). The relationship between 4D models of Thiagarajan et al. (1974) and the stages of R & D of Borg and Gall (1983) are shown in the following table.

Table 1 The relationship between 4D model of Thiagarajan et al. and the stages of R & D from Borg & Gall

No.	Model 4D dari Thiagarajan et al.(1974)	R & D dari Borg & Gall (1983)
1.	<i>Define</i>	Information gathering and planning
2.	<i>Design</i>	Design the initial product
3.	<i>Develop</i>	Limited-scale testing, major product revision, large-scale testing, operational product revision, field testing, and final product revision
4.	<i>Disseminate</i>	Socialisation and implementation

The activities on this development research are at the large-scale testing or implementation (Develop) and for this article is at will belimited at major product revision. The draft is presented in Figure 1.

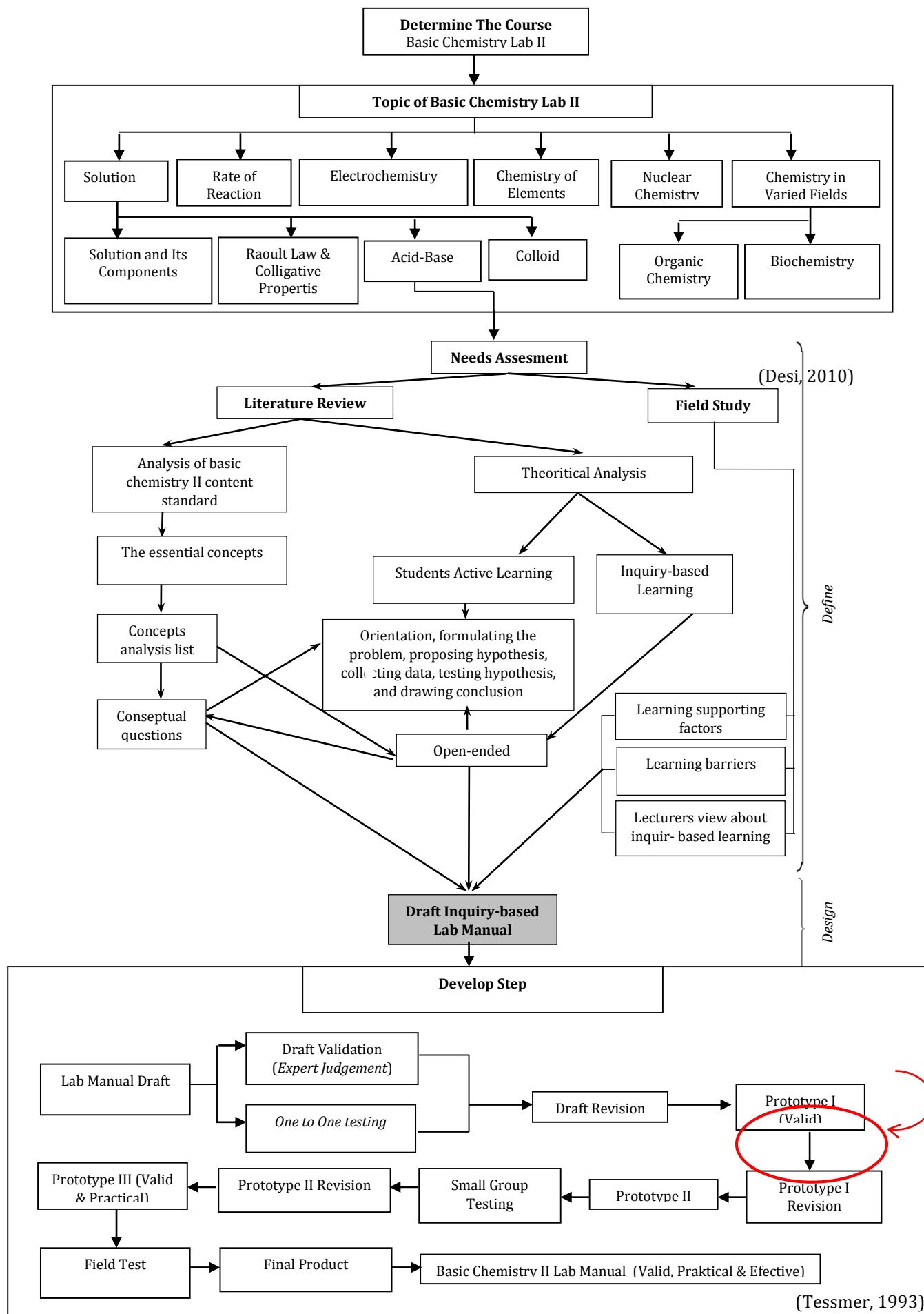


Figure 1. Steps in 4D model (Define, Design, dan Develop)

The theoretical framework for this research is illustrated in Figure 2.

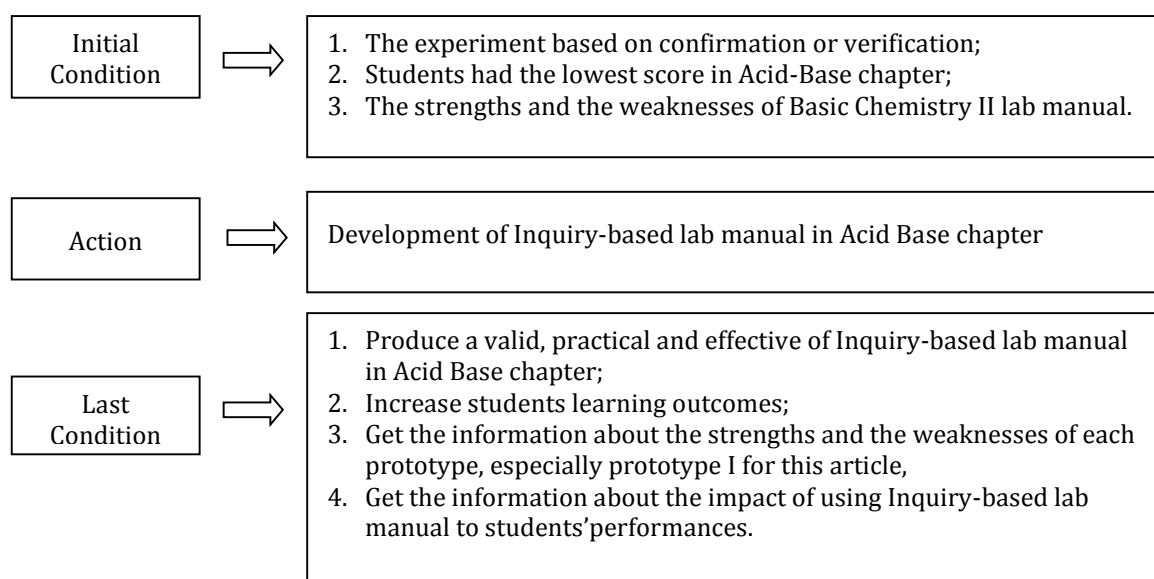


Figure 2. Research Framework

METHODOLOGY

This is Development Research which aims to develop Inquiry-based Lab Manual in Acid Base chapter which is valid, practical and effective. Research subjects for *expert judgment* are pedagogical, content and design experts, while for one to one test is students of Chemistry Education Study Program.

Procedure

The procedure of this research based on Figure 1, but for this article limited to one to one testing and product revision in development of inquiry-based lab manual step.

1) Needs Assesment (Define)

All of informations were got from literature review and field study. Literature review consists of (1) analyse the content standard (competencies standard and basic competencies) in order to get the essential concepts, (2) analyse the essential concepts to get list of concepts analysis, (3) propose the indicators for inquiry-based learning, (4) make some conceptual questions, and (5) arrange performance test according to inquiry-based learning. We got some data from field study, such as (1) learning facilities (chemistry laboratory and textbooks) and the problems which had been faced by lecturers in conducting basic chemistry lab II experiments.

2) Design Inquiry-based Lab Manual Draft (Design)

Literature reviews and field study give some information which are very useful for designing Inquiry-based lab manual draft (see Figure 1).

3) The Development of Inquiry-based Lab Manual (Develop)

a. Experts Judgment

Lab manual draft was validated by pedagogical, content and design experts. Experts gave very useful suggestions for revising the draft and gave valid Prototype I.

b. Limited Testing and Major Product Revision

There are two kinds of testing: one to one and small group testing. Prototype I was tested in one to one testing. It was conducted in class and done by 3 students of Chemistry Education Study Program which represented students population. There were some revisions for prototype I and resulted prototype II.

Data Collecting

1) Validation Sheet

Validation sheet consists of 29 descriptors for pedagogical aspect, 19 descriptors for content aspect, and 7 descriptors for design aspect. The experts should circle one of score on validation sheet according to the alternative answers.

2) Questionnaire

The instrument for practicality test of the prototype I was a questionnaire that contained 15 descriptors with five alternative answers and score ranged 1-5 and accompanied by the comment column.

Data Analysis

1) Analysis of Validation Sheet Data

Analysis of validation data used formula:

$$\text{Validation Score} = \frac{\text{Number of Score}}{\text{Number of Item}} \quad (\text{Widoyoko, 2012})$$

Classification table was arranged according to pedagogical, content and design aspects and score ranged from 1.0 to 5.0 (not valid to very valid).

2) Analysis of Questionnaire Data

Questionnaire data were analysed using *Likert Scale* formula:

$$\text{Score} = \frac{\text{Number of Score from Responden}}{\text{Number of Responden} \times \text{Number of Item}} \quad (\text{Widoyoko, 2012})$$

Practicality classification table was arranged according to pedagogical, content and design aspects and score ranged from 1.0 to 5.0 (not practical to very practical).

RESULT AND DISCUSSION

Expert Judgment

At design stage, we developed lab manual draft through a set of draft development steps. Then, experts (HT, SJ and HL) validated the draft according to pedagogical, content and design aspects and each of them gave the score. There were a set of draft revision to get the revised one (prototype I) according to expert suggestions and we got score for pedagogical, content, and design aspects. Score for prototype I validation according to pedagogical aspect was 4,00. It showed that prototype I was valid in encouraging students to search and found the answer of the problem by himself, developed student life skill, and appropriated in presentation techniques. Score for prototype I validation according to content aspect was 4,21. It showed that prototype I was valid in the accuracy of material, the use of the term and symbol, up to date experiment, and appropriated in presentation techniques. Score for prototype I validation according to design aspect was 4,57. It showed that prototype I was very valid in lab manual design.

The average score for three aspects was 4.14 representing Inquiry-based Lab Manual in Acid Base Chapter which met valid aspect. According to National Academy of Science

(1996), inquiry is one of the best science learning in pedagogical and content aspect. It can build content understanding and develops students'skills and abilities. The product of this step is Valid Prototype I.

One to One Testing

The one to one testing involved three students and measured lab manual practicality. Score for one to one testing was 4,20. It showed that prototype I was in practical category and it helped students to do experiment in laboratory, encouraged them to find and develop their abilities. According to questionnaire data, this manual is interesting because of colorful, communicative and applicative to use in daily life. Kanli and Yagbasan (2006) said that lab manual and learning in laboratory must attractive and encourage students to find and solve the problem, also think scientifically and creatively. The content must relate to environment so they interest to the facts, phenomena and certain things which encourage them to think and discuss like scientist. There was a revision to prototype I to get prototype II which meets valid and practical aspect and will be tested in the next level.

The Strengths and Weaknesses of Protoype I

According to validation sheet, questionnaire data, and suggestions from expert and students, we can analyse the strengths and the weaknesses of prototype I (see table 2 and 3).

Table 2. The Strengths of Prototype I Using Validation and Questionnaire Data

No	The Strengths
1.	Presented in attractive form
2.	Students understand the procedure easily
3.	Use communicative language
4.	Lab materials or experiment related to daily life
5.	The lab manual is colorful
6.	There is a guidance to make experiment report
7.	There is study literature page
8.	There is glosarium page
9.	The illustration or picture is very clear
10.	Students understand the sentence in lab manual easily
11.	The experiment encourages the student to know more about chemistry concepts deeply
12.	The experiment gives students a higher order thinking skills

Table 3. The Weaknesses of Prototype I Using Experts and Students Suggestions

No	Weakness	Experts Suggestion
1. Pedagogical		
1.	List of Content	Don't use word "BAB" in list of content page.
2.	Procedure	Let the students arrange their own procedure.
3.	Reference	Add inquiry references: book or journal
2. Content		
4.	Preface	Add name of expert in preface page.

5.	List of Content	Pay attention with page number. There are some mistakes in content, such as glosarium section has the same page with picture list section.
6.	Introduction	Put reference in Competence Standard and Basic Competencies section.
7.	Concept Map	Put reference in Concept Map section.
8.	Problem Page	Don't use brand, such as "Promag" word, replace it with Antacid.
9.	Report Template	Put reference in Report Template section.
10.	Attachment	Put reference in Table 2. Acid-Base Indicators.
3. Design		
11.	Cover	<ol style="list-style-type: none"> 1. Change word "Panduan" to "Petunjuk" and "Penulis" to "Penyusun". 2. "Petunjuk Praktikum" must be put in the top line, followed by "Kimia Dasar II Materi Larutan Asam Basa" and below it, put "Berbasis Inquiry". 3. Put editor name. 4. Fix the layout and cover size with paper size. 5. Add "Program Studi Pendidikan Kimia" in the bottom, followed by "Jurusan Pendidikan Matematika dan Ilmu Pengetahuan Alam", "Fakultas Keguruan dan Ilmu Pendidikan", Universitas Sriwijaya", "2013".
12.	Picture & Table	Word colour must be black for picture and table.
13.	Glosarium	The word colour for term must be blue and the explanation in brown colour.
Students Suggestion in One to One Testing		
14.	Tools	You should put all tools in one page in order to all students do not use wrong tools.
15.	Column Space	You should reconsider the column size and choose another colour.
16.	Font Size	<ol style="list-style-type: none"> 1. Pay attention with font size. 2. Pay attention with the printed version.

CONCLUSIONS

1. Prototype I is valid according to pedagogical, content and design aspect and practice for guiding students to conduct acid base experiments in laboratory. The score respectively is 4.14 and 4.20.
2. Prototype I had strengths and weaknesses in terms of design, language and content so it needed to be revised and trial at a further step .

REFERENCES

- Farikhayati. (2009). Pengembangan Buku Petunjuk Praktikum Kimia Untuk SMP/MTs Kelas VII Berdasarkan Kurikulum Tingkat Satuan Pendidikan (KTSP) [Development of Chemistry Lab Manual for Seventh Grade Students in Junior High School based on Education Unit Level Curriculum]. *Skripsi*. Yogyakarta: Fakultas Sains dan Teknologi Universitas Islam Negeri Sunan Kalijaga.
- Fay, M.E., Grove, N.P., Towns, M.H., & Stacey, L.B. (2007). A rubric to characterize inquiry in the undergraduate chemistry laboratory. *Chemistry Education Research and Practice*, 8(2), 212-219.
- Fitriyanti. (2008). Upaya Meningkatkan Hasil Belajar Kimia Siswa di Kelas XI IPA 1 SMA Negeri 1 Indralaya Melalui Penerapan Model Inkuiri [An Effort to Improve Students' Learning Outcomes in the Class XI IPA 1 in SMAN 1 Indralaya through the Implementation of Inquiry Model]. *Skripsi*. Indralaya: FKIP Universitas Sriwijaya.

- Lesmini, B & Desi. (2011). *Petunjuk Praktikum Kimia Dasar 2 [Basic Chemistry 2 Lab Manual]*. Indralaya: Program Studi Pendidikan Kimia FKIP Universitas Sriwijaya.
- Hofstein, A., Navon, O., Kipnis, M., & Naaman, R.M. (2004). Developing student's ability to ask more and better questions resulting from inquiry-type chemistry laboratories. *Journal of Research in Science Teaching*, 42(7), 791-806.
- Kanli, U., & Yagbasan, R. (2006). The effects of a laboratory approaches on the development of university students' science process skills and conceptual achievement. *Essays in Education, Special Edition*, 143-153.
- Lane, J. L. (2007). *Inquiry Based Learning*. Penn State: Schreyer Institute.
- McMillan, J. H. & Schumacher, S. (2001). *Research in Education: A Conceptual Introduction*. 5th Ed. New York: Addison Wesley Longman.
- National Academy of Sciences. (1996). *National Science Education Standards*. Washington, DC: National Academy Press.
- Oguz-Unver, A., & Arabacioglu, S. (2011). Overview on inquiry based and problem based learning methods. *Western Anatolia Journal of Educational Science. Special Issue*, 303-310.
- Roestiyah. (2012). *Strategi Belajar Mengajar [Learning Strategy]*. Jakarta: Rineka Cipta.
- Rupiah. (2010). Penggunaan Bahan Ajar Kimia Dasar I (Ikatan Kimia dan Kesetimbangan Kimia) Berwawasan Pedagogi Materi Subjek untuk Meningkatkan Kualitas Pembelajaran pada Program Studi Kimia FMIPA FKIP Unsri [Development of Basic Chemistry I Teaching Material (Chemical Bonding and Chemical Equilibrium) based on Pedagogical Subject Matter to Improve Learning Quality in Chemistry Study Program FMIPA FKIP Unsri]. *Skripsi*. Indralaya: FKIP Universitas Sriwijaya.
- Sagala, S. (2010). *Konsep dan Makna Pembelajaran [The Concept and Meaning of Learning]*. Bandung: Alfabeta.
- Sanjaya, W. (2009). *Strategi Pembelajaran Berorientasi Standar Proses Pendidikan [Learning Strategy Oriented to Educational Process Standard]*. Jakarta: Kencana Prenada Media Group
- Tessmer, M. (1993). *Planning and Conducting Formative Evaluation*. Philadelphia, London: Kogan Page.
- Trianto. (2010). *Mendesain Model Pembelajaran Inovatif-Progresif [Designing Innovative-Progressive Learning Model]*. Jakarta:Kencana.
- Widoyoko, E.P. (2012). *Teknik Penyusunan Instrumen Penelitian [Techniques of Designing Research Instruments]*. Yogyakarta. Pustaka Pelajar
- Yamin, M. (2011). *Paradigma Baru Pembelajaran [The New Paradigm of Learning]*. Jakarta: Gaung Persada.